TESTS AND INSPECTIONS FOR PROCESS CONTROL
OF
MONOLITHIC CIRCUITS

FINAL REPORT

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SUMMARY

The key elements for the procurement of high reliability integrated circuits by NASA is the determination that the vendor's circuit design is reliable and that he maintains an organization and adequate controls to assure that each circuit manufactured and delivered meets the reliability capabilities inherent in the device design. A demonstration of device design reliability can be obtained by accelerated testing of relatively small sample sizes. However, the demonstration that each circuit manufactured has the reliability level inherent in the design is not feasible. To give adequate assurance that all circuits manufactured are of a uniform high reliability level, the vendor must have adequate process controls.

The included process controls are intended to illustrate the types of controls which are found to be effective for the manufacture of silicon monolithic circuits. They may serve as a basis for the evaluation of a vendor's capability. They may not be the most effective controls which can be established, but they are the most effective which Motorola has been able to develop to date. They are not suitable for all manufacturing processes but they have been found to be suitable for Motorola's manufacturing processes. They do not all influence reliability but rather generally have a more significant effect on electrical characteristics and yield. They are not inflexible but will rather be adjusted as other controls are found to be more effective. Indeed, if these controls were not being constantly reviewed, the current state of the monolithic circuit development and production would not be possible. This entire program is offered as a basis for evaluation rather than the basis of control by NASA.

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SECTION I

1.0 INTRODUCTION

The purpose of this program is to describe the process controls which have been found to be effective for the manufacture of high reliability silicon monolithic integrated circuits and could serve as a basis for NASA qualification of monolithic circuit manufacturers.

"The scope of this program includes designation of process steps which should be qualified as part of Line Qualification." (See Figure 1, page 8.) The degree to which the process steps described would serve as a basis for Line Qualification depends to a large extent upon the definition for "Line Qualification." If Line Qualification means that these are elements which should be considered in the evaluation of an integrated circuit manufacturer's capability, then the process control steps described could serve as a basis for NASA qualification. If, on the other hand, Qualification required the establishment of a specific set of process controls which are to be monitored by NASA, such a program will be doomed.

The included process controls are those which Motorola has found to be effective for the manufacture of silicon monolithic circuits. Several factors must be considered in evaluating such process controls: (1) The majority of these controls have been established to optimize yield and electrical performance and may have little effect in determining the reliability of the circuits. (2) These controls have been found to be effective; however, this does not mean that another set of controls could not be equally or perhaps even more effective. (3) These controls are applicable to Motorola's manufacturing process. If the processes were different, and there are many different manufacturing processes used to make reliable integrated circuits, obviously the controls would have to be those which are suitable for the process under consideration.

Thus, the described controls represent a current status at those which have been found to be effective for Motorola's production of monolithic silicon circuits. The continuing engineering effort being applied to all of Motorola's processing operations will undoubtedly result in more effective process controls. It would not be wise to feel that these controls will not be changed or that they will be effective for all manufacturers.

The process controls described are quite extensive. They cover the full range of manufacturing from the growth of the silicon crystal to the final encapsulation of the device. A number of controls are described for each significant production stage. These are intended to assure optimum yield of devices with desired electrical characteristics and maximum reliability. They are included here as an illustration of the types of controls which may be used and could well serve as the basis for the evaluation of a manufacturer's facilities. Since the majority of the manufacturing steps included are common to any manufacturer's production of silicon monolithic circuits, the controls in effect at these steps are worthwhile for consideration as a part of qualification evaluation.

The reliability of any integrated circuit depends upon the inherent reliability of the design and processes used for its manufacture and the degree of process control exercised to assure that each circuit in the population possesses a reliability as close as possible to the optimum. It is presumed that the reliability of the process and design can be fairly well demonstrated by testing a reasonably small number of devices. The reason for the evaluation of process control as an element of qualification is to permit NASA to assess its effectiveness in assuring a uniformly high reliability product. If the vendor's process control is well thought out and effectively carried through, confidence in the reliability of his production will be high.

The overwhelming majority of the controls listed are designed primarily to optimize electrical characteristics and yield. Some, however, do have a high reliability aspect. Those with a significant reliability aspect are wafer, die, die bond, and wire bond inspections. The final two inspections actually have an even higher reliability aspect than the first two. At these most significant steps, Motorola has established Quality Assurance check points. These four inspection points should have common elements for all vendors and thus are perhaps somewhat more suitable for comparative evaluation than the other in-process control points described. In these four key areas, it may be feasible for NASA to establish a certain degree of control which will afford a basis for reliability assurance. It must be realized that the control criteria which will be effective at each of these key points depend to a large extent upon the particular manufacturing process used. Inspection criteria which are adequate for one manufacturing process may be completely inappropriate for another manufacturing process. However, for any manufacturer to have some criteria and inspection at these four key points is probably appropriate. The inspection criteria which Motorola has found to be suitable for these points are included in Section IV.

The scope for this program includes process controls on the ionized water, mask making and package fabrications. These have not been specifically included because they do not appear to be appropriate. The controls which have been established on the ionized water are referred to in the steps which use this water. No specific controls on mask making have been established. This is because the mask making operation is basically an engineering function and although most masks are made by Motorola's Mask Shop, mask sets are also procured from outside vendors. It is feasible to inspect sets to determine conformance with specifications, and the controls which enter into their manufacture need not be specified. The same considerations are true for packages. Although Motorola does make a number of its own integrated circuit packages, many are procured from outside vendors. All packages that are procured from vendors or supplied by Motorola come through Incoming Inspection and are inspected to the same criteria. Thus, the production control used for the manufacturing of these packages would not be appropriate for consideration as a basis for qualification by NASA.

This report contains a flow chart (Section II) depicting the significant process steps for the manufacture of monolithic integrated circuits. Motorola is not at this time in regular production of monolithic integrated circuits other than the NPN bipolar type. In general, the process steps described will also be suitable for PNP complementary and unipolar circuits. Some adjustments may have to be made in the inspection criteria for these circuits, but these should not be very significant.

Section III includes a description of the process controls which have proven to be effective at each of the control points included in the flow chart. The descriptions of these controls are adequate to demonstrate their scope and purpose. They do not, however, include the myriad of details which is necessary to carry out the actual process control inspection.

Section IV includes the five In-Process Quality Assurance specifications for the points which Motorola has found most effective from a reliability viewpoint. These specifications include procedures illustrating frequency of sampling, general inspection criteria, and methods of reporting.

1.1 SCOPE

The scope of work, as stated in RFQ DCN 1-6-40-64546, is: The contractor, as an independent contractor and not as an agent of the Government, shall furnish all of the necessary personnel, facilities and material and otherwise do all things necessary for establishing a program of Line Qualification based on process controls for producing monolithic circuits for NASA use, in accordance with the tasks described below:

1. In sequential flow chart format list the basic process steps which the contractor currently uses to produce typical NPN bipolar monolithic circuits and at which the contractor normally makes a measurement, test, or inspection to maintain statistical control over the production line, and thus achieve a homogeneous product with good yeild and reliability. These steps should start with substrate preparation and go through sealing. They should include deionized water, mask making, and packages, but no other indirect materials.

2. On the flow chart the contractor shall indicate those process steps which should be qualified as a part of Line Qualification as reasonable assurance to NASA that the vendor's line is capable of producing monolithic circuits.

3. For each process step listed in 2, indicate the measurements, tests, and inspections, or any other type of statistical control which should be included in the qualification of that step as a reasonable assurance to NASA that the process step is in consistent control. Give the percent accuracy required of the instruments used, a description of the procedure (include frequency of test and sample size), min-max limits, tolerances, or criteria,

used by the contractor, and whether the measurement, test or inspection results in a reading, a tabular record, a strip chart, or a distribution. Make it clear as to whether the test, measurement, or inspection is performed on equipment, the test pattern, or the completed circuit.

4. Indicate for each measurement, test, or inspection made the action taken if tolerances are exceeded.

5. The contractor shall indicate, for each measurement, test, or inspection described for the control of the process steps to be qualified, whether the measurement, test, or inspection applies equally well to PNP, complementary, and unipolar circuits, and, if not, what changes or additions should be made to make it applicable.

SECTION II

2.0 FLOW CHART

The significant steps in the manufacture of silicon monolithic circuits on the Motorola process is included in Figure 1. Twenty-five production steps from crystal seed preparation through centrifuge screening of completed product have been included. Most of these process flow steps are probably similar in most respects for all manufacturers' processes. However, certain other steps such as glass passivation, Step 16, are unique to Motorola. Steps 5 through 12 are repeated several times for the manufacturer of an integrated circuit wafer. Isolation diffusion, base diffusion and emitter diffusion all require the same general sequence of steps. For simplicity, these repeated steps have not been included.

Process controls are in effect at each of these manufacturing steps. These process controls are aimed at improved yield to specify electrical characteristics in most cases and maximum reliability in others. They have proven to be effective for Motorola's current manufacturing process.

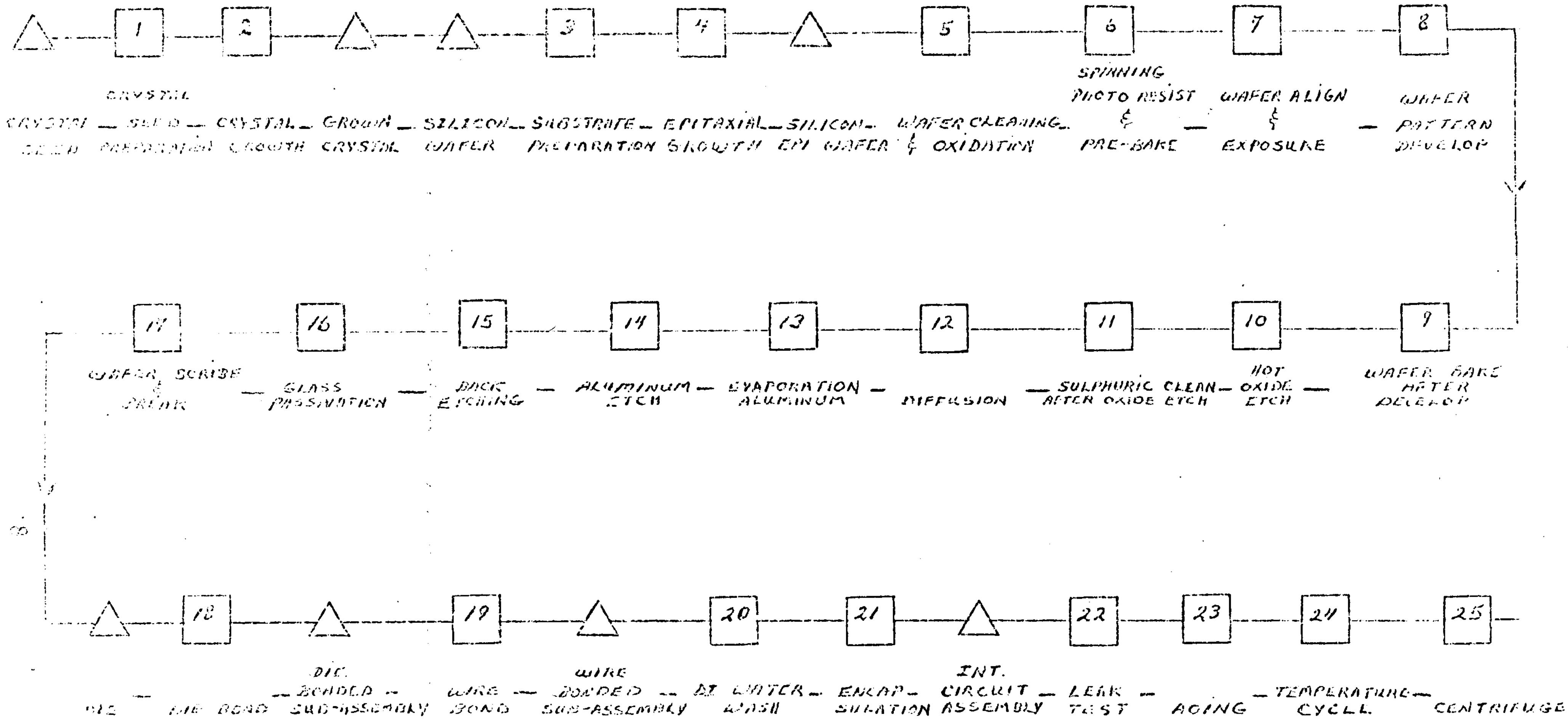
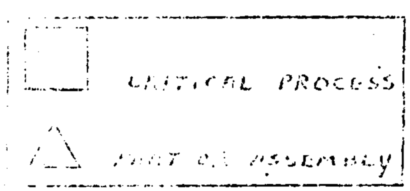


Figure 1. Integrated Circuit Process Flow Chart

LEGEND



SECTION III

3.0 PROCESS CONTROL STEPS

For each of the process control steps included in the previous section, a detailed description of controls in effect has been prepared. These controls are described in this section. In general, a number of controls have been included for each of the significant process steps. Each of these controls at each step is described in some detail in a uniform manner in the following subsections.

3.1 METHOD OF CONTROL

This element describes the several process controls which are in effect at each of the significant manufacturing stations. These controls will consist of machine control, operator control, product measurements all by both Production and a Quality Assurance person. The method of control is described in a simple manner but adequately enough to portray the control method. Each method of control is identified with a capital letter in the subsequent elements of process description.

3.2 METHOD OF SAMPLING

Included in this section is the frequency of sampling for each of the methods of control described.

3.3 MEASUREMENT PROCEDURE

This section describes the element which is evaluated to determine the degree of control. This may be either the equipment or the work output from the station.

3.4 METHOD OF MEASUREMENT

This section describes for each method of control the method of measurement. This may be an instrument used to calibrate a piece of equipment or to evaluate products.

3.5 RANGE OF PERMISSIBLE MEASUREMENTS

Included in this element is the range of parameter measurement which is permitted without the process being considered out of control. For those processes and measurement procedures which have criteria which cannot be briefly described, the specific specification would have to be reviewed to determine the applicable criteria. In these cases, the term "criteria" is included under this heading. The majority of the controls in these categories are those associated with visual inspection of the process.

3.6 METHOD OF RECORDING

The method used to record the results and evaluation of each method of control is listed.

3.7 METHOD OF ANALYSIS

The corrective action which is taken if the process is determined to be out of control is included under this heading. This may include machine adjustment, material rework, or scrapping of material.

The process controls which are in effect at each of the inspection stations are described in an abbreviated manner in this section. However, this description should be adequate to determine the effectiveness of a process control program for the evaluation of potential suppliers of silicon monolithic circuits.

PROCESS STEP 1 - CRYSTAL SEED PREPARATION

Method of Control

(A) Type probe of seed crystal

(B) Four point probe resistivity of seed crystal

(C) Orientation of shaped seed

(D) Etch and dislocation count of seed

Method of Sampling

(A) Sample size is 100 percent.

(B) Crystals are sampled 100 percent.

(C) 100 percent of crystal; 0 percent of seeds

(D) 100 percent of crystals; 0 percent of seeds
Each end of crystal is sampled.

Measurement Procedure

(A) The crystal is prepared by removing oxide from a region extending over the length of the crystal. This entire region is then probe typed.

(B) Each crystal is measured for resistivity in the center of both sawed ends. If one end is cut, cuts and further measurements are made until the specification is met.

(C) The crystal is mounted on the saw, and a sample is cut off; this sample is then checked for orientation on sawed surface. The crystal is adjusted on the saw to correct any irregularities and another sample is taken. When the crystal's sawed surface is within specifications, the seeds are cut.

(D) The crystal ends are etched for dislocation counts before the seeds are cut from the crystal. After etching, dislocations are counted five separate times in a 20 X 7.5 eyepiece. This count is compared to emperical data for a reading given in dislocations per square centimeter.

Method of Measurement

(A) Either thermal or rectifying type probes are used. Equipment used is: Type Probes - Motorola.

(B) Four Point Probe - Equipment used is: Digital Readout Four Point Probe; Digital Voltmeter - Cimron Pacific - Model P9200B; DC Preamplifier - Cimron Pacific - Model 6812B; Power Supply - Motorola.

(C) A Bragg Reflection measurement is made. Equipment used is: Phillips Electronic Instruments, Type 12068/6.

(D) A microscope, (B & L Metallurgical), at 20 X 7.5 Dislocations within this field are counted and the count is then calculated.

Range of Permissible Measurements

(A) Readings indicate go or no-go conditions.

(B) Readings must be $\geq$ 10 ohm-cm or the material is rejected.

(C) Readings must be within 10 minutes of the (111) plane.

(D) $\leq 2500/cm^2$ or it is out of specification.

Method of Recording

(A) Readings are recorded on the crystal log sheet.

(B) Readings are recorded on the crystal log sheet.

(C) No recording is required as prior inspection assures proper orientation.

(D) Pass or fail is recorded on the crystal log sheet.

Method of Analysis

(A) If three crystals are out of specification, engineering is notified. If out of specification, crystals are either transferred to another device or are scrapped.

(B) If three crystals are out of specification, engineering is notified. Crystals which are out of specification are either put into another group or are scrapped.

(C) Operator judgment

(D) If three crystals are out of specification, engineering is notified. If crystals are out of specification, they are either supplied for another device or they are scrapped.

PROCESS STEP 2 - CRYSTAL GROWTH

Method of Control

(A) Type probe of grown crystal

(B) Four point probe resistivity check of crystal ends

(C) Go-no-go crystal diameter check

Method of Sampling

(A) 100 percent

(B) 100 percent of crystals at both ends

(C) Total length of crystal

Measurement Procedure

(A) The crystal is prepared by removing the oxide from a region extending over the length of the crystal. This entire region is then probe typed.

(B) The measurement is taken at the center of both cropped ends of the crystal. If one of the ends is out of specification then a cut is made and the readings are repeated until both ends are in specification.

(C) Test is on crystal.

Method of Measurement

(A) Either thermal or rectifying type probes are used.

(B) Measurements are of the four point probe type. Equipment used is Digital Read-out Four Point Probe, Digital Voltmeter - Cimron Pacific - Model P9200B, DC Preamplifier - Cimron Pacific - Model 6812B, Power Supply - Motorola.

(C) A gauge is run over the crystal. Set width gauge made to given specifications.

Range of Permissible Measurements

(A) Readings indicate either go or no-go conditions.

(B) This range is dependent upon the device specification.

(C) As per specification of the individual device

Method of Recording

(A) Readings are recorded on the crystal log sheets.

(B) Readings are recorded on the crystal log sheets.

(C) Pass or fail is recorded on the crystal log sheet.

Method of Analysis

(A) If three (3) crystals continue to be out of specification, then Engineering is notified. If crystals are out of specification they are either put into another device or they are scrapped.

(B) If three (3) crystals continue to be out of specification, then Engineering is notified. If crystals are out of specification, they are either put into another device or they are scrapped.

(C) If crystal is undersized, it is either scrapped or put into another device. If crystal is oversized, it is ground.

PROCESS STEP 3 - SUBSTRATE PREPARATION

Method of Control

(A) Diameter check of grown crystal

(B) X-ray orientation check of each crystal

(C) Micrometer measure of wafer thickness after sawing

(D) Visual cleanliness inspection after cleaning

(E) Each etch load is sampled (5 out of 25), etched, and sampled again. This determines removal by etching. A control chart is kept on this data. The control chart plots the ΔT between the nominal thickness and the actual thickness. Overetched material is scrapped. Underetched material is reetched. Yields show up on IBM card. Gauge into 0.0 X 0.001 inch thickness categories.

(F) Four Point Probe resistivity check

(G) Visual inspection of surface quality and cleanliness after polish

(H) Four Point Probe resistivity check

Method of Sampling

(A) 100 percent for every crystal

(B) 100 percent

(C) Every tenth wafer is checked.

(D) 100 percent

(E) 100 percent

(F) 100 percent

(G) 100 percent

(H) Sample is 6.5 percent AQL.

Measurement Procedure

(A) Crystal
(B) Wafer
(C) Wafer
(D) Wafer
(E) Center of the wafer
(F) Measurement taken in center of wafer
(G) Wafer
(H) Measurement taken in center of wafer

Method of Measurement

(A) Micrometer (hand) Brown & Sharpe Model 20-1
(B) X-ray equipment is used to determine Bragg angles. Wafer is cut from crystal and cut surface is tested. No other samples are taken. Corrections are made until specification is met on cut surface as crystal is cut.
(C) Micrometer (hand), Brown & Sharpe - Model 20-1
(D) Inspected under light using normal vision for the following: fractures, breaks, and quality of saw pattern
(E) Sigmatic Gauge - Sigma Instrument Company - $\pm$ 5 millionths
(F) Three (3) Digital Systems:
    (1) Digital Voltmeter - Non-Linear Systems - Mdl. V34B - Preamplifier - NLS. - Model 141 Power Supply - Homemade
    (2) Digital Voltmeter - Hewlett Packard Mdl - 3440A High Gain/Auto Range - HP - 3443A Constant Current Power Supply - Electronic Measurements - Model 6612

(3) Digital Voltmeter - NLS. - Model 141. Constant Power Supply - Electronic Measurements - Model 6612

(G) Inspection under light using normal vision. Look for scratches, pits, fractures, breaks, dimples, twins.

(H) Three (3) Digital Systems:

(1) Digital Voltmeter - Non-Linear Systems - Mdl. V34B - Preamplifier - NLS. - Model 141 Power Supply - Homemade

(2) Digital Voltmeter - Hewlett Packard Mdl - 3440A High Gain/Auto Range - HP - 3443A Constant Current Power Supply - Electronic Measurements - Model 6612

(3) Digital Voltmeter - NLS. - Model Y34B Preamplifier - NLS. - Model 141. Constant Power Supply - Electronic Measurements - Model 6612

Range of Permissible Measurements

(A) As per specification, it can vary from $0.7'' < D < 3'' \pm 0.1''$.

(B) $\pm$ 30' vertical $\pm$ 15' horizontal

(C) As per specification, it can vary from $4 < 25$ mils $\pm$ 0.3 mil.

(D) Criteria

(E) 0.0001 inch

(F) As per specification, machine is good to $\pm$ 2.5 percent.

(G) Criteria

(H) As per specification

Method of Recording

(A) At this point the crystal measurements are transferred to an IBM card. A weight check is made after grinding and also recorded on an IBM card.

(B) Rejection is recorded on log sheet, either in or out of specification.

(C) Number of rejects are recorded on log sheet.

(D) Here, good wafers are counted and the lot total is recorded on an IBM card and a wafer's per gm yeild is recorded.

(E) Each group has a thickness requirement.

(F) Yield is recorded on the IBM card.

(G) Yield goes on the IBM card. Control charts are kept on the following:

    (1) Taper across wafer (10 wafers per device once each shift)

    (2) Thickness (Sample 5 per device once each shift.)

    (3) Percent defective (Fifty wafers at random are inspected for surface, breaks, etc.)

(H) Log records either pass or fail.

Method of Analysis

(A) If the entire crystal remains in specification, operation is under control. If corrections are needed, production maintenance is called.

(B) If crystal is cut out of specification, it is scrapped.

(C) If out of specification, wafer is scrapped. If specification is not met, machine is repaired.

(D) A monthly yield report is circulated.

(E) Wafers which fall into no group are scrapped. Count is recorded on IBM card.

(F) If out of specification, wafer either goes into another device or is scrapped.

(G) If lot fails, then it is 100 percent detailed and rejected samples are scrapped or put into another device. Total wafer yields are published.

(H) If lot fails, then it is 100 percent detailed and rejected samples are scrapped or put into another device. Total wafer yields are published.

PROCESS STEP 4 - EPITAXIAL GROWTH

Method of Control

(A) Check epitaxial thickness by weight difference.

(B) Four Point Probe for sheet resistance

(C) Visual inspection for surface quality

(D) Visual comparison of standards for oxide thickness

(E) Sample Q.A. Inspection - visual, resistivity and thickness

Method of Sampling

(A) 50 percent sample size - A selected sample which allows detailing (on buried layer only the 5 to 10 percent middle wafer is tested)

(B) Minimum is approximately 30 percent and group is detailed as necessary (buried layer can be 5 to 10 percent depending on wafer size).

(C) 100 percent

(D) 100 percent

(E) Visual - 100 percent, resistivity - 6.5 percent AQL, thickness - 100 percent

Measurement Procedure

(A) Wafers are weighed before and after epitaxy. Deposition and weight is transferred in thickness deposition.

(B) Wafer

(C) Wafer

(D) Wafer comparison

(E) Wafer

Method of Measurement

(A) Micrometer (hand) Brown & Sharpe 1 inch Model 1011 Sundstrand Machine Tool - Belt Grinder

(B) Four Point Probe Type

(C) Visual inspection with normal room light and no optics, for pits, spikes, scratches, fractures, cloudy surfaces, dimples, twins

(D) Oxide Chart

(E) Resistivity by Four Point Probe

Range of Permissible Measurements

(A) Specification requires to nearest 0.1 micron

(B) To the nearest ohms per square up to 3 significant figures

(C) Pits: No major pits, 5 minor pits, 25 micropits. Scratches: Over 2/3 wafer diameter. Spikes: None Fractures: None. Cloudy Surfaces: None. Dimples: None. Twins: None.

(D) To specification

(E) Criteria

Method of Recording

(A) (1) Weight is recorded on envelope. (2) Weight range is recorded on box. (3) Weight sheet [discarded after three (3) months.] (4) Number which is in specification is recorded on device log.

(B) (1) Envelope (2) Box (range) (3) Evaluation log (range) (4) Furnace log sheet

(C) Yield is kept on evaluation log. Furnace log is kept.

(D) Furnace log, range on box, range on evaluation log

(E) Lot yield is recorded in Q.A. log. All readings are recorded on Resistivity Data Sheet (file). Reject readings are recorded on Discrepancy forms.

Method of Analysis

(A) If out of specification, wafer is either put into another device or scrapped. If it goes out of specification, a change is made. If it oscillates, Engineering is notified.

(B) If the wafer is out of specification, use another specification or scrap it. Changes are made to stay in specification.

(C) If wafer is out of specification, it is scrapped. If one wafer run is 60 percent out of specification, a maintenance procedure is followed and Engineering is notified.

(D) Adjustments are made to stay in specification. Otherwise, Engineering is called.

(E) Disposition of Rejects - Engineering Discrepancy forms are sent to (1) Q.A. File (2) Engineering.

PROCESS STEP 5 - WAFER CLEANING AND OXIDATION

Method of Control

(A) (1) Furnace Profile Monitoring
(2) Monitoring Recorder Check

(B) Test runs for oxide thickness and uniformity are made.

(C) Inspection of every wafer

Method of Sampling

(A) (1) Daily
(2) Profiled monthly or as needed

(B) Prior to a run after furnace profile

(C) Inspection of every wafer

Measurement Procedure

(A) (1) Performed on Diffusion Furnace
(2) Equipment

(B) Wafers

(C) Wafers

Method of Measurement

(A) (1) Recorder, Pt-Rh Thermocouple - Leeds & Northrup $\pm$ 0.05 percent error - Model 69862 (Note: Calibrated every three (3) months)
(2) Leads & Northrup Millivolt Potentiometer $\pm$ 0.05 percent Pt-Pt-Rh-----$\pm$ 0.3°C (Note: Calibrated once a month)

(B) Visual and interfermometer

(C) Visual and Microscope (A&O) American Optical Inst. Div. Series 56

Range of Permissible Measurements

(A) (1) $\pm$ 1°C for A (ZO) inch flat zone Min.
(2) $\pm$ 1°C for A (ZO) inch flat zone Min.

(B) $\pm$ 10 percent

(C) Reject all wafers with epi spikes. Wafers must be clean. Approximately 2 percent other types damaged areas will be tolerated.

Method of Recording

(A) (1) Strip chart and written profile
(2) Strip chart and written profile

(B) Furnace Log Book kept

(C) Record number of rejects in log book.

Method of Analysis

(A) (1) Recorder, monitoring, furnace profile, daily Recorder deviation in excess of 2°C will require that the furnace be reprofiled.
(2) Recorder is repaired if found to be out of calibration.

(B) If oxide is not thick enough, wafer is reoxidized. If oxide is too thick, pass if <15,000 Å. If oxide >15,000 Å, strip and reoxidize.

(C) Reject all wafers with epi spikes. Reject wafers with > 2 percent other type damage.

PROCESS STEP 6 - SPINNING PHOTORESIST AND PREBAKE

Method of Control

(A) Spinner strobed for correct speed

(B) Oven temperature

Method of Sampling

(A) Daily

(B) Checked a minimum of 5 times a day

Measurement Procedure

(A) Spinner equipment

(B) Prebake oven

Method of Measurement

(A) Strobotac, Type 1531-A - General Radio Company, Concord, Massachusetts ----- ± 1 percent

(B) Visual reading of sym-ply-trol meter, reading checked once a month or sooner if required by drawers with thermocouple. (a) chromel-alumel thermocouple (Motorola made) ± 0.3°C (b) Leeds & Northrup Potentiometer 8686 ----- ± 0.03 percent + 3 microvolts.

Range of Permissible Measurements

(A) ± 300 RPM

(B) ± 5°C

Method of Recording

(A) No record is kept.

(B) Visual - No record is kept.

Method of Analysis

(A) Adjust spinner to correct speed. Wafers passed that have been spun at below or above specifications (will be caught at inspection).

(B) Correct temperature (previous wafers passed will be caught at inspection).

PROCESS STEP 7 - WAFER ALIGN AND EXPOSURE

Method of Control

(A) Check exposure light intensity.

(B) Check air pressure.

(C) Check timer setting.

(D) Check microscope for filter in optical system.

(E) Mask inspection

Method of Sampling

(A) Daily

(B) Each time operator sits down at that station.

(C) Each time operator sits down at that station.

(D) Each time operator sits down at that station.

(E) Each time operator inserts mask in tool.

Measurement Procedure

(A) Equipment

(B) Equipment

(C) Equipment

(D) Equipment

(E) Masks

Method of Measurement

(A) ±1 percent repeatability
Ultraviolet intensity - Model UV 411-A
International Light Inc., Newburyport, Mass.

(B) Fisher gauge (0 - 60 PSI)

(C) Cramer timer 1123 ---- ± 0.2 sec

(D) Green filter from American Optics 2511

(E) Dyna-Zoom Optics (10X eyepiece - 5X objective with (1 - 2X Zoom)

Range of Permissible Measurements

(A) ±2 Gilway units
(B) ± 1/2 PSI
(C) ± 1/2 sec
(D) None - only require green light
(E) If mask has roughly 5 percent damage by KMER or scratching, it is removed and replaced by new mask.

Method of Recording

(A) Record in log book.
(B) Visual
(C) Visual
(D) Visual
(E) Visual and noted on mask for reject information.

Method of Analysis

(A) Replace bulb. (Wafers passed - inspection will catch it.)
(B) Adjust to correct value before starting the operation.
(C) Adjust to correct value before starting the operation.
(D) Install light if missing before starting the operation.
(E) Reject mask and note on mask only for reject data.

PROCESS STEP 8 - WAFER PATTERN DEVELOP

Method of Control

(A) Check pressure and time settings.

(B) Visual inspection (production)

(C) Visual inspection (Q.A.)

Method of Sampling

(A) Each time operator sits down to use the machine.

(B) All wafers in all lots

(C) Lot sampling

Measurement Procedure

(A) Equipment

(B) Wafer

(C) Inspected wafer

Method of Measurement

(A) Visual on Cramer timer 1123 ---- ± 0.2 sec

(B) Microscope, Wild - Heerbrugg, Model M20

(C) Microscope, Wild - Heerbrugg, Model M20

Range of Permissible Measurements

(A) ± 1/2 PSI, ±1/2 sec

(B) Criteria

(C) Criteria

Method of Recording

(A) Visual - No record kept.

(B) Tabular record

(C) Tabular record and control charts

Method of Analysis

(A) Set meters correctly. (No correction made on wafers if exposed incorrectly - will be caught at inspection.)

(B) Redo or repair

(C) Discrepant Process Report and material returned to production for corrective action.

PROCESS STEP 9 - WAFER BAKE AFTER DEVELOP

Method of Control

(A) Check oven temperature.

(B) Check gas flow.

Method of Sampling

(A) Minimum of 5 times per shift

(B) Minimum of 5 times per shift

Measurement Procedure

(A) Equipment

(B) Equipment

Method of Measurement

(A) Visual reading of sym-ply-trol meter reading: check once a month or sooner, if required by drawers with thermocouple. (a) Chromel - Alumel Thermocouple (Motorola made) ±0.3°C (b) Leeds and Northrup Potentiometer 8686 - tolerance ±0.03 percent + 3 microvolts.

(B) Visual of Brocks flow meter 6-65A glass float ± 2 CFH at 14.7 PSI.

Range of Permissible Measurements

(A) ±50°C

(B) ±6 CFH

Method of Recording

(A) Visual - no record is kept.

(B) Visual - no record is kept.

Method of Analysis

(A) Adjust for correct temperature. If temperature was below specification, rebake. If temperature was over specification, then inspect wafers for correct color. If it appears overbaked, strip and redo. This is not recorded.

(B) Adjust flow meter - Pass wafers. This is not recorded.

PROCESS STEP 10 - HOT OXIDE ETCH

Method of Control

(A) Inspection of trial wafers

(B) Etch temperature monitoring

Method of Sampling

(A) Prior to every run

(B) Before and during every run

Measurement Procedure

(A) Trial wafer

(B) Etch solution

Method of Measurement

(A) Microscope, Wild-Heerbrugg, Model M20

(B) Thermometer (-20° to 150°C) $\pm$ 1/4°C

Range of Permissible Measurements

(A) Limit etch time to clear oxide from areas or until KMER starts to lift.

(B) $\pm$ 5°C

Method of Recording

(A) Visual - no record is kept other than operator noting time for that run.

(B) Visual - no record is kept.

Method of Analysis

(A) Increase or decrease etch time to remove oxide or to prevent KMER lifting. If lifting cannot be repaired by rebaking, then strip wafers and reprocess.

(B) Adjust hot plate to correct temperature. Etching will stop until solution is correct.

PROCESS STEP 11 - SULFURIC CLEAN AFTER OXIDE ETCH

Method of Control

(A) Acid change and beaker cleaned
(B) Monitor acid temperature
(C) Visual Inspection (production)
(D) Visual Inspection (Q.A.)

Method of Sampling

(A) After every 10 boatloads of wafers, beaker is refilled.
(B) Three (3) times per shift minimum
(C) All wafers in all lots
(D) Inspected lots sampled hourly

Measurement Procedure

(A) Equipment
(B) Acid
(C) Wafer
(D) Inspected Wafer

Method of Measurement

(A) Number of boatloads of wafers
(B) Thermometer, (-20° to 260°C) ± 1/4°C
(C) Microscope, Wild-Heerbrugg, Model M20
(D) Microscope, Wild-Heerbrugg, Model M20

Range of Permissible Measurements

(A) N/A
(B) ± 10°C
(C) Criteria
(D) Criteria

Method of Recording

(A) No reading required

(B) Visual - not recorded

(C) Tabular record

(D) Tabular record and control charts

Method of Analysis

(A) No report

(B) Adjust hot plate for correct temperature.

(C) Redo or repair

(D) Discrepant Process Report and material returned to production for corrective action.

PROCESS STEP 12 - DIFFUSION-ISOLATION, BASE, EMITTER

Method of Control

(A) Furnace Profiles

(B) Test runs to determine correct gas flows and predeposition time for predeposition cycle (oxide uniformity and Xj and Ps uniformity, electrical properties)

(C) Control wafers sample probed

(D) Source temperature

Method of Sampling

(A) Minimum of once a month or sooner, if recorders indicate the need

(B) Prior to running actual material at emitter diffusion only, and at start of shift for base and isolation

(C) After each diffusion

(D) Prior and during each diffusion run

Measurement Procedure

(A) Predeposition and redistribution furnaces

(B) Test wafers for base and isolation and emitter, but in addition, use slivers on actual wafers at emitter.

(C) Control wafers

(D) Equipment

Method of Measurement

(A) Recorder, and Pt-Pt-Rh thermocouple (1) Recorder Leeds and Northrup, Model 69862 $\pm$0.05 percent error calibrated once every three (3) months. (2) Pt-Pt-Rh

thermocouple made at Motorola $\pm 0.3°C$, calibrated every month. (3) Leeds and Northrup millivolt Potentiometer, 8686 ± 0.03 percent + 3 microvolts.
(4) Zeiss interference microscope - $\pm$ 300 Å.
(5) Tektronix curve tracer, type 575, Model 122C.
(6) a. Four Point Probe "Head" Acronetics, Inc. Model 1025-M $\pm$ 0.25 percent, Palo Alto, California, 220 California Avenue. b. Constant Current Source Electronic Measurements, Eatontown, New Jersey, Model C612 - 0.15 percent of setting. c. Digital Voltmeter, Hewlett Packard, Model 3439A --- $\pm$ 0.05 percent reading $\pm$/digit.

(B) Interferometer, four point probe, visual, 575 curve tracer

(C) Interferometer, four point probe, visual

(D) Temperature controlled equipment plus thermometer

PROCESS STEP 13 - EVAPORATION-ALUMINUM

Method of Control

(A) Evaporator substrate temperature monitored

(B) Control wafers or chips are checked for evaporation layer thickness.

Method of Sampling

(A) During every run

(B) After every run

Measurement Procedure

(A) Equipment

(B) Control wafers

Method of Measurement

(A) Visual ± 5°C (1) Calibrated with Leeds and Northrup Potentiometer ± 0.03 percent + 3 microvolts as required or minimum once every three (3) months. (2) Surface checked as required or minimum of once every three (3) months. Surface thermometer, Pacific Transducer 575 CM - ±2°C

(B) Interference Microscope ±500 Å "Zeiss"

Range of Permissible Measurements

(A) ±15°C

(B) ±2000 Å

Method of Recording

(A) Visual (a go-no-go operation)

(B) Thickness is recorded for each run and all lot numbers are noted for that run.

Method of Analysis

(A) Notify maintenance for correction of heater elements of sym-ply-trol reading.

(B) Wafers are accepted by Engineers if signed off, or lot stripped and metal reevaporated.

Range of Permissible Measurements

(A) $\pm 1°C$ for a 20-inch flat zone minimum
(B) Varies with material (± 5 percent to ± 10 percent).
(C) Varies with material (± 5 percent to ± 10 percent).
(D) $\pm$ 1°C

Method of Recording

(A) Recorded on strip chart and written recording of profiles.
(B) Recorded in furnace log book.
(C) Recorded in furnace log book.
(D) Recorded in furnace log book.

Method of Analysis

(A) Recorder, monitoring furnace profile, checked daily. Recorder deviation in excess of 2°C will require that the furnace be reprofiled.
(B) Repeat tests with correct adjustments made.
(C) If Ps is too high, rediffuse for isolation and base. If Ps is too low, reject out for base and isolation. If beta is too low at emitter, rediffuse for shorter basewidth. If beta is too high and DBD too low, reject out.
(D) Adjust dial to produce correct temperature.

PROCESS STEP 14 - ALUMINUM ETCH

Method of Control

(A) Solution,hot plate temperature monitored

(B) Rebake, hot plate temperature monitored

(C) Visual inspection

Method of Sampling

(A) Prior and during every run

(B) Prior and during every run

(C) Every wafer before rebake

Measurement Procedure

(A) Equipment

(B) Equipment

(C) Wafer

Method of Measurement

(A) Thermometer - (-20°to 150°C) ±1/4°C - Leeds and Northrup 8686 - ±0.03 percent + 3 microvolts

(B) (1) Motorola built ON-OFF thermocouple feed to sym-ply-trol. This denotes temperature as well as controlling it.-- ± 2°C (2) Check pyrometer and thermocouple once a month by drawers with a separate thermocouple which is monitored by a potentiometer. Chromel Alumel Thermocouple - ±0.3°C "Motorola made"

(C) Microscope, Wild-Heerbrugg Model M20.

Range of Permissible Measurements

(A) $\pm$ 2°C

(B) (a) $\pm$ 5°C (b) $\pm$ 3°C (between thermocouple reading and sym-ply-trol)

(C) Criteria will vary with device. (Normally must have less than 5 percent bad die due to bridging, incomplete etching, undercutting.)

Method of Recording

(A) Visual reading of thermometer. Do not begin operation until correct. Continually check during run and make necessary adjustments to correct it.

(B) (1) Visual (b) recorded in log book.

(C) Recorded on daily log sheet (run lot number, operator, date, inspector).

Method of Analysis

(A) Operator does not begin or discontinues when temperature is not in specification. If it cannot be controlled, maintenance is notified.

(B) (1) Notify foreman for correction of temperature.
(b) Adjust sym-ply-trol reading to be the same as the thermocouple reading.

(C) Wafer is reetched. If it cannot be saved, have metal stripped and redo.

PROCESS STEP 15 - BACK ETCHING

Method of Control

(A) Hot plate temperature check

(B) Etch time varies with reaction.

Method of Sampling

(A) Before and during every run

(B) During each etch on all wafers (Check the amount removed on a wafer for each new batch of etch used.)

Measurement Procedure

(A) Equipment

(B) Wafers

Method of Measurement

(A) Surface thermometer (Pacific Transducer Corp. No. 575 CM) $\pm$ 2°C

(B) Observe etching of wafers

Range of Permissible Measurements

(A) $\pm$ 8°C

(B) Vary etch time to reaction occuring $\pm$ 30 seconds.

Method of Recording

(A) Visual

(B) Visual

Method of Analysis

(A) Adjust hot plate to correct temperature.

(B) Adjust time of etch during etch cycle.

PROCESS STEP 16 - GLASS PASSIVATION

Method of Control

(A) Determine usable zone for correct oxide deposition.

(B) Source, line and heat tunnel temperatures

Method of Sampling

(A) When first turned on and continuously thereafter

(B) At start of each shift or when trouble may develop

Measurement Procedure

(A) Blank monitor wafers

(B) Equipment

Method of Measurement

(A) Visual inspection of color on wafer

(B) (1) Thermometer (0° - 150°C) ± 1/4°C (2) Motorola built pyrometer for heater tunnel ± 2°C (3) Calibration of pyrometer by a thermocouple (Motorola-made ± 0.3°C) and potentiometer - (Leeds and Northrup Millivolt Potentiometer 8686 - ± 0.03 percent + 3 microvolts)

Range of Permissible Measurements

(A) ± 700 Å of oxide

(B) (line) ± 5° to ± 10°C depending on device requirements (source) ± 1° to ± 2°C depending on device requirements (heat tunnel) ± 5° to ± 10°C depending on device requirements

Method of Recording

(A) Visual only

(B) Recorded in furnace log book.

Method of Analysis

(A) If oxide is too thin, run again; if it is too thick, pass, but make adjustments on equipment.

(B) Report in log book, adjust controls to produce correct results. Wafers are passed, if oxide is too thick; if oxide is too thin, wafers can be run again.

PROCESS STEP 17 - WAFER SCRIBE AND BREAK

Method of Control

(A) Scribe and break a control wafer.

(B) Visual inspection (Production)

(C) Visual inspection (Q.A.)

Method of Sampling

(A) Beginning of each shift and after equipment maintenance

(B) All dice after wafer break

(C) Inspected dice from each production inspector every two (2) hours

Measurement Procedure

(A) Control wafer

(B) Die

(C) Inspected die

Method of Measurement

(A) Microscope - Wild-Heerbrugg, Model M20

(B) Microscope - Wild-Heerbrugg, Model M20

(C) Microscope - Wild-Heerbrugg, Model M20

Range of Permissible Measurements

(A) Criteria

(B) Criteria

(C) Criteria

Method of Recording

(A) None

(B) Tabular record

(C) Tabular record and control charts

Method of Analysis

(A) Equipment shut down and maintenance performed.

(B) Equipment shut down and maintenance performed.

(C) Discrepant process report and material returned to Production for corrective action.

PROCESS STEP 18a - DIE BOND-PYROCERAM

Method of Control

(A) Furnace profiled
(B) Monitor furnace gas flow and temperature meter settings
(C) Package inspection
(D) Visual inspection (Production)
(E) Visual inspection (Q.A.)

Method of Sampling

(A) Weekly
(B) Daily
(C) Prior to belt loading
(D) All die bonded subassemblies
(E) Die bond operators' and inspectors' work sampled daily.

Measurement Procedure

(A) Sealing furnace
(B) Sealing furnace
(C) Flat package
(D) Die bonded subassemblies
(E) Die bond subassemblies from operators and inspected subassemblies from inspectors

Method of Measurement

(A) Recorder-Barber Coleman, Model 8061-27000, 0.05 percent
(B) Visual
(C) Visual
(D) Visual
(E) Visual

Range of Permissible Measurements

(A) $\pm$ 5°C with a minimum of 30 minutes flat zone
(B) Criteria
(C) Criteria
(D) Criteria
(E) Criteria

Method of Recording

(A) Strip chart
(B) Tabular record
(C) Tabular record
(D) Tabular record
(E) Tabular record and control charts

Method of Analysis

(A) Process Engineering notified; equipment maintenance.
(B) Process Engineering notified; equipment maintenance.
(C) Engineering notified; defective material held.
(D) Material repaired or rejected; operator retrained or equipment maintenance.
(E) Discrepant Process Report and material returned to Production for corrective action.

PROCESS STEP 18b - DIE BOND - Au-Si EUTECTIC

Method of Control

(A) Equipment profiled.
(B) Temperature and gas settings checked
(C) Package inspection
(D) Visual inspection (Production)
(E) Visual inspection (Q.A.)

Method of Sampling

(A) Weekly and after maintenance
(B) Daily
(C) Prior to belt loading
(D) All die bonded subassemblies
(E) Die Bond operators' and inspectors' work sampled daily

Measurement Procedure

(A) Equipment
(B) Equipment
(C) Header
(D) Die bonded subassemblies
(E) Die-bond subassemblies from operators and inspected subassemblies from inspectors

Method of Measurement

(A) Minimite Potentiometer, Model 80200, $\pm$ 0.5 percent with Chromel-Alumel Thermocouple
(B) Visual
(C) Criteria
(D) Criteria
(E) Criteria

Range of Permissible Measurements

(A) $\pm$ 5°C
(B) $\pm$ 5°C
(C) Criteria
(D) Criteria
(E) Criteria

Method of Recording

(A) Tabular record is kept.
(B) Tabular record is kept.
(C) Tabular record is kept.
(D) Tabular record is kept.
(E) Tabular record and control charts are kept.

Method of Analysis

(A) Equipment shutdown and maintenance
(B) Equipment shutdown and maintenance
(C) Engineering is notified; defective material is held.
(D) Material is repaired or rejected. Operator is retrained or equipment is maintenanced.
(E) Discrepant process report and material are returned to Production for corrective action.

PROCESS STEP 19 - WIRE BOND

Method of Control

(A) Machine is profiled.

(B) Monitor machine settings

(C) Wire pull test

(D) Visual inspection (Production low power and high power preseal)

(E) Visual Inspection (Q.A.)

Method of Sampling

(A) Weekly and after maintenance

(B) Daily

(C) Twice (2) daily

(D) All wire bonded subassemblies

(E) Wire bond operators' and inspectors' work sampled daily.

Measurement Procedure

(A) Equipment

(B) Equipment

(C) Wire bonded subassembly

(D) Wire bonded subassembly

(E) Wire bonded subassembly

Method of Measurement

(A) L & N Potentiometer, Model 8686 - 0.03 percent $\pm$ 3 mV with Chromel-Alumel Thermocouple

(B) Visual

(C) Motorola Wire Pull Tester

(D) Microscope, B & L Stereozoom and Wild-Heerbrugg, Model M20

(E) Microscope, B & L Stereozoom and Wild-Heerbrugg, Model M20

Range of Permissible Measurements

(A) Header temperature $\pm$ 15°C, needle weight $\pm$ 20 G

(B) Header temperature $\pm$ 15°C, needle weight $\pm$ 20 G

(C) Criteria

(D) Criteria

(E) Criteria

Method of Recording

(A) Tabular record is kept.

(B) Tabular record is kept.

(C) Tabular record and control chart are kept.

(D) Tabular record is kept.

(E) Tabular record and control chart are kept.

Method of Analysis

(A) Machine is adjusted.

(B) Machine is adjusted or shut down.

(C) Machine is adjusted or shut down.

(D) Material is rejected or repaired; operator is retrained or equipment maintenance is performed.

(E) Discrepant Process reports and material are returned to Production for corrective action.

PROCESS STEP 20 - DEIONIZED WATER - PREENCAPSULATION WASH

Method of Control

(A) Wash station is checked.
(B) Alcohol dip rinse is drained and refilled.
(C) Check water flow into cascade.

Method of Sampling

(A) Beginning of each shift
(B) Every two (2) hours
(C) Beginning of each shift

Measurement Procedure

(A) Equipment (Purity meter readings, dial settings on control panels - Timer and Pressure Gauge)
(B) Equipment
(C) Equipment

Method of Measurement

(A) Purity Meter - Barnstead, PM-19
Timer - Creamer 1123, $\pm$ 0.2 sec
(B) Visual
(C) Flow Meter - Visual

Range of Permissible Measurements

(A) Loop input $\pm$ 1-1/2 megohms CM; Loop output $\pm$ 1 megohm CM; Cascade center $\pm$ 1-1/2 megohms CM
(B) Criteria
(C) Criteria

Method of Recording

(A) None

(B) None

(C) None

Method of Analysis

(A) Equipment shut down and maintenance performed.

(B) Equipment shut down and maintenance performed.

(C) Equipment shut down and maintenance performed.

PROCESS STEP 21a - ENCAPSULATION - FLATPACKS

Method of Control

(A) Furnace profiled
(B) Monitor furnace gas flow and temperature meter settings
(C) Visual inspection (Production)

Method of Sampling

(A) Weekly
(B) Daily
(C) All capped units

Measurement Procedure

(A) Sealing furnace
(B) Sealing furnace
(C) Capped units

Method of Measurement

(A) Recorder - Barber Coleman, Model 8061-27000, 0.05 percent
(B) Visual
(C) Microscope, B & L Sterozoom

Range of Permissible Measurements

(A) $\pm$ 5°C with a minimum of 30 minutes flat zone
(B) Criteria
(C) Criteria

Method of Recording

(A) Strip chart
(B) Tabular record
(C) Tabular record

Method of Analysis

(A) Process Engineering notified; equipment maintenance.

(B) Process Engineering notified; equipment maintenance.

(C) Defective units are repaired.

PROCESS STEP 21b - ENCAPSULATION - TO-5

Method of Control

(A) Welder settings are checked.

(B) Moisture content in Dry Box is monitored.

(C) Squeeze test for weld integrity is performed.

(D) Gross leak test is performed (by Production).

(E) Fine and gross leak tests are performed (by Q.A.).

(F) Visual inspection is performed (by Production).

Method of Sampling

(A) Prior to each run

(B) Before and during each run

(C) Six dummy packages are welded at beginning of each shift and after maintenance or electrode change.

(D) Every 2 hours; after maintenance; after electrode change on 6 welded dummy packages

(E) Every 2 hours production is sample leak tested.

(F) First 25 units are welded from each production lot.

Measurement Procedure

(A) Equipment

(B) Equipment

(C) Welded dummy packages

(D) Welded dummy packages

(E) Welded production devices

(F) Welded production devices

Method of Measurement

(A) Visual

(B) Moisture Monitor, Consolidated Electrodynamics Corp., Model 26-303

(C) Squeeze cap minimum of 2/3 diameter

(D) Bubble test

(E) Veeco, Model MS-9AB or NRC 925 Helium Leak Detector and bubble test

(F) Visual

Range of Permissible Measurements

(A) Criteria

(B) 100 ppm Maximum

(C) Criteria

(D) Criteria

(E) Criteria

(F) Criteria

Method of Recording

(A) None

(B) None

(C) None

(D) Tabular record

(E) Tabular record

(F) None

Method of Analysis

(A) Equipment shut down and maintenance performed.

(B) Equipment shut down and maintenance; production in.

(C) Dry Box to be rebaked
Equipment shut down and maintenance performed.

(D) Equipment shut down and maintenance performed.

(E) Discrepant Process Report and material is returned to Production for corrective action.

(F) Equipment shut down and maintenance performed.

PROCESS STEP 22 - LEAK TEST

Method of Control

(A) Sample fine and gross leak test (Q.A.)

(B) Helium leak detector calibration

Method of Sampling

(A) All production lots

(B) Twice per shift and after any maintenance

Measurement Procedure

(A) Hermetic devices

(B) Equipment

Method of Measurement

(A) Bubble test (TO-5) or dye penetrant test (Flatpack) and Veeco Model MS-9AB or NRC 925 helium leak detector

(B) Veeco SC4 Sensitivity Calibrator

Range of Permissible Measurements

(A) Criteria

(B) Criteria

Method of Recording

(A) Tabular record is kept.

(B) Tabular record is kept.

Method of Analysis

(A) Discrepant Process Report and material is returned to Production for corrective action.

(B) Equipment shut down and maintenance performed.

PROCESS STEP 23 - AGING (STABILIZATION BAKE)

Method of Control

(A) Oven Profile

Method of Sampling

(A) Monthly

Measurement Procedure

(A) Equipment

Method of Measurement

(A) L & N Potentiometer, Model 8686, 0.03 percent $\pm$ 3 mV

Range of Permissible Measurements

(A) $\pm$ 20°C

Method of Recording

(A) Tabular

Method of Analysis

(A) Equipment shut down and maintenance performed.

PROCESS STEP 24 - TEMPERATURE CYCLING

Method of Control

(A) Refrigerator profile

(B) Temperature oven profile

Method of Sampling

(A) Monthly

(B) Monthly

Measurement Procedure

(A) Equipment

(B) Equipment

Method of Measurement

(A) L & N Potentiometer, Model 8686, 0.03 percent $\pm$ 3 mV

(B) L & N Potentiometer, Model 8686, 0.03 percent $\pm$ 3 mV

Range of Permissible Measurements

(A) $\pm$ 5°C

(B) $\pm$ 5°C

Method of Recording

(A) Tabular record is kept.

(B) Tabular record is kept.

Method of Analysis

(A) Equipment shut down and maintenance performed.

(B) Equipment shut down and maintenance performed.

PROCESS STEP 25 - CENTRIFUGE

Method of Control

(A) Speed checked

(B) Speed checked

(C) Visual inspection

Method of Sampling

(A) Every 14 days

(B) Every 14 days

(C) Prior to centrifuge loading

Measurement Procedure

(A) Drive pulley

(B) High speed spindle

(C) Multispeed attachment, spindles, pulley belt, tachometer shaft, rubber tip, loading jigs

Method of Measurement

(A) Strobe, No. 71221 - Model 1531-A, General Radio, ± 3 percent

(B) Strobe, No. 71221 - Model 1531-A, General Radio, ± 3 percent

(C) Visual

Range of Permissible Measurements

(A) ± 50 RPM

(B) ± 300 RPM

(C) Criteria

Method of Recording

(A) Tabular record is kept.

(B) Tabular record is kept.

(C) Tabular record is kept.

Method of Analysis

(A) Equipment shut down and maintenance performed.

(B) Equipment shut down and maintenance performed.

(C) Equipment shut down and maintenance performed.

SECTION IV

4.0 IN-PROCESS OF QUALITY ASSURANCE SPECIFICATIONS

The overwhelming majority of the process controls described in the preceding section are carried out by manufacturing personnel. There are, however, certain manufacturing process steps which include additional controls carried out by In-Process Quality Assurance personnel. In general, the In-Process Quality Assurance controls are aimed at controlling those processes which may contribute to less than optimum device reliability. Device reliability is not, of course, the only consideration for the establishment of in-process control points. Indeed, improved yield to the better process control is also a very significant element.

In the wafer preparation and device assembly areas, In-Process Quality Assurance controls have been established at five Process Steps. These are:

Process Step	8	Wafer Pattern Develop
Process Step	11	Sulfuric Clean After Oxide Etch
Process Step	17	Wafer Scribe and Break
Process Step	18	Die Bond
Process Step	19	Wire Bond

The specifications describing these quality assurance controls are included.

MOTOROLA
Semiconductor
Products Inc.

ENGINEERING & MANUFACTURING SPECIFICATIONS DEPARTMENT

IN-PROCESS Q.A.

REVISION RECORD SHEET

PRODUCT GROUP: INTEGRATED CIRCUITS PRODUCT LINE:

TITLE: IN-PROCESS Q.A. INSPECTION PROCEDURE AFTER PHOTO RESIST DEVELOP-VISUAL

SPD 4520

NO. MCA54215W

REV.	ES	DATE	ASC CODE	DESCRIPTION OF CHANGE
G	ES-8312	3-12-88	IC-1018	Steps 1.1, 2.1 and 2.1.3 changed

PRINT NO.

NO. MCA54215W

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MOTOROLA Semiconductor Products Inc.

PRODUCTION SPECIFICATIONS DEPARTMENT

IN-PROCESS Q.A. PROCEDURE

PRODUCT GROUP: Integrated Circuits   PRODUCT LINE:

TITLE: In-Process Q. A. Inspection Procedure after Photoresist Develop - Visual

MCA54215W
NO. 12M516620

Scope: This specification covers the procedure to be followed in inspecting the following parts:

PART NUMBER	DESCRIPTION	USED ON
	Wafer, SI-EPI	All Integrated Circuit Lines

Equipment Required:

Microscope, Wild (Heerbrugg)
Tweezers

Procedure:

1. Sampling Plan

G 1.1 The sampling plan will be to inspect 10% of the wafers in a wafer run or a minimum of (3) wafers, whichever applies from each production inspector every (2) hours after production inspection after developing at Isolation, Base, Emitter, Pre-Ohmic and Metal Mask for all applicable requirements listed under 2. below. Inspection will be done according to the Product Line criterions.
If there are any reject wafers, the entire wafer run will be returned to Production for re-inspection. After re-inspection, the run will be re-submitted to Q.A.

2. Unit Processing

G 2.1 Inspect all wafers under a microscope magnification, prescribed by product line criteria for the following categories of defects. Maintain a count of the number of defectives in each category and the total number of wafers inspected and rejected by each inspector. Maintain count on Motorola Form No. SPD-3952. Refer to Visual Aids for typical defects.

						SPECIFICATION
	[illegible]	G				MCA54215W
ES-3225		F				NO [illegible]
ES-20[illegible]	[illegible]	E				
MEMO	DATE	ISS	MEMO	DATE	ISS	PAGE 1 OF 2

2.1.1 Mask misalignment

2.1.2 No KMER

2.1.3 Bad Mask

2.1.4 KMER Lifting

2.1.5 Not developed out

2.1.6 Pinholes

2.1.7 Wrong pattern

2.1.8 Scratches on wafer surface

2.1.9 Poor contact

3. Data Processing

3.1 Compute the percent defective for total failures in each wafer run. This percent shall be figured on the basis of total sample size.

i.e. $\frac{(\text{total failures} \times 100)}{\text{Total sample}}$

3.2 Maintain a percent defective chart, Motorola Form No. SPD-1321, using the value obtained in 3.1. Plot (1) point per sample inspection.

3.3 Compute and maintain a percent defective chart for each inspector.

NOTE: All data generated by other shifts shall be kept on separate charts.

Compute and maintain a percent defective chart for the Q.A. Develop Inspection operations.

3.4 Indicate on the charts any adjustment or change made to improve the process as well as any inadvertent change.

3.5 An "Out-of-Control" process shall be defined as one in which (1) or more wafers have in excess of 15% defective die (see wafer reject chart) (do not include die on periphery or test patterns). If this situation exists, a Discrepant Process Report, Motorola Form No. SPD-1833-R1, shall be issued to the cognizant production personnel. All Discrepant Process Reports will be recorded on Motorola Form No. SPD-3814 at the time of issuance and the date recorded when returned. The Discrepant Process

Reports must designate corrective action taken and be signed by the production foreman and product engineer. All reports must be returned within a reasonable time. If the Discrepant Process Reports are not returned within (48) hours, notify your Q.A. Supervisor for further investigation.

4. Should any question arise concerning these inspection procedures, contact your immediate Q.A. supervisor.

5. All inspected wafers will be returned to the Wafer Fabrication Area to be processed in the normal manner.

WAFER INSPECTION - MASKING AREA - AFTER CLEAN

DATE	OP.	RUN NO.	NO. OF WAFERS	PINHOLES	SCRATCHES	UNDERCUTTING	STAINING	UNDERETCHED	MISSING METALLIZATION	BAD METALLIZATION	GOLD BACKING			ACCEPTED	SPUN	ALIGN	ETC

Semiconductor
Products Division

ASSEMBLY		DEVICE	CHARACTERISTIC	TOLERANCE
DEPT.	SAMPLE SIZE	REMARKS		

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75

TIME

DATE

INITIALS

MOTOROLA FORM NO. SPD-1321

QUALITY CONTROL DISCREPANT PROCESS REPORT

Q.C. INSP.____________ DATE:__________ SHIFT:_____ OPERATOR:____________

TYPE OF SAMPLE:____________ SAMPLE SIZE:_______ TIME OF SAMPLE:____________

SAMPLE RESULTS:________________________________

CORRECTIVE ACTION PERFORMED:________________________________

MOTOROLA FORM NO. SPD-1039-R1 - FACE

ENGINEERING

ACTUAL		APPEARANCE	
MISSING WIRE		< 3 BONDS	
EXCESSIVE LOOP		OFF BOND	
LIFTED BOND		BOND SPACING	
BROKEN WIRE		> 60° ANGLE	
MISBOND		INNER 2/3	
OVER-BOND		EXCESSIVE LOOP	
90° ANGLE		TAIL	
INC. BOND		EXTRA BOND	
CHOP. BOND		LIFTED BOND	
SMEAR. BOND		OVER-BOND	
WEAK BOND			
TAILS			
OFF BOND			
SHORT			
FOREIGN MATTER			
SUBSTRATE SHORTS			
LIFTED B. AREA			
EXCESSIVE WIRE			
METALIZATION			
DIE			

MOTOROLA FORM NO. SPD-1833-R1 • BACKER

DISCREPANT PROCESS REPORT LOG

Date Issued	Operation	Issued To	Reason	Date Ret'd	Date Issued	Operation	Issued To	Reason	Date Ret'd

Prepared by John Durso

MOTOROLA
Semiconductor
Products Inc.

PRODUCTION SPECIFICATIONS DEPARTMENT

IN-PROCESS Q.A. PROCEDURE

PRODUCT GROUP: Integrated Circuits PRODUCT LINE:

TITLE: In-Process Q.A. Inspection Procedure - After H_2SO_4 Clean - Visual

NO. MCA5421W
12M516610

Scope: This specification covers the procedure to be followed in inspecting the following parts:

PART NUMBER	DESCRIPTION	USED ON
	Wafer, SI-EPI	All Integrated Circuit Lines

Equipment Required:

Microscope
Tweezers

Procedure:

1. Sampling Plan

1.1 A random sample of 10% of every (1) hour's production after all H_2SO_4 cleaning operations will be taken by the Q.A. Inspector and will be inspected for all applicable requirements listed under 2, below.

2. Unit Processing

2.1 Inspect all wafers under a microscope (100X), minimum magnification, for the following categories of defects. A wafer will be rejected in accordance to the percent defective die on it, see wafer reject chart. Maintain a count of the number of wafers inspected and rejected by each inspector. Maintain count on Motorola Form No. SPD-1264. See visual aids for typical rejects.

2.1.1 Undercutting
2.1.2 Pinholes
2.1.3 Scratches of wafer surface
2.1.4 Any other obvious defects
2.1.5 Under etched

3. Data Processing

3.1 Compute the percent defective for total failures. This percent shall be figured on the basis of total sample size.

i.e $\frac{(\text{total failures} \times 100)}{\text{total sample}}$

						SPECIFICATION
						MCA5421W
EO-6225		D				NO. 12M516610
13-2881		D				
MEMO	DATE	ISS	MEMO	DATE	ISS	PAGE 1 OF 7

WAFER REJECT CHART

15% REJECT DIE
PER ONE INCH WAFER
(Less Test Patterns and
Outer 1-1/2 Rows)

SIZE OF DIE	AMOUNT OF REJECTS DIE TO PASS WAFER AT	AMOUNT OF REJECT DIE TO REJECT WAFER
25	171	172
30	107	108
35	80	81
40	56	57
45	41	42
50	33	34
55	24	25
60	21	22
60 x 80	15	16
60 x 1100	11	12

3.2 Maintain a percent defective chart, (Motorola Form No. SPD-1321, for the H_2SO_4 clean operations) using the value obtained in 3.1. Plot (1) point per sample inspection.

NOTE: All data generated by other shifts shall be kept on separate charts.

3.3 Indicate on the charts any adjustment or change made to improve the process as well as any inadvertent change.

3.4 An "Out-of-Control" process shall be defined as one in which (1) or more points (percent defective) are in excess of the control limits. If this situation exists, a Discrepant Process Report, Motorola Form No. SPD-1833-R1, shall be issued to the cognizant production personnel. All Discrepant Process Reports will be recorded on Motorola Form No. SPD-3814 at the time of issuance and the date recorded when returned. The Discrepant Process Reports must designate corrective action taken and be signed by the production foreman and product engineer. All reports must be returned within a reasonable time. If the Discrepant Process Reports are not returned within (48) hours, notify your Q.A. Supervisor for further investigation.

4. Should any question arise concerning these inspection procedures, contact your immediate Q.A. Supervisor.

5. All inspected wafers will be returned to the wafer fab. area to be processed in the normal manner.

WAFER INSPECTION - MASKING AREA - AFTER CLEAN

DATE	OP.	RUN NO.	NO. OF WAFERS	PINHOLES	SCRATCHES	UNDERCUTTING	[illegible]	UNDERETCHED	[illegible]	[illegible]	[illegible]			ACCEPTED	SPUN	ALIGN	ETC

Semiconductor
Products Division

ASSEMBLY		DEVICE	CHARACTERISTIC	TOLERANCE
DEPT.	SAMPLE SIZE	REMARKS		

TIME

DATE

INITIALS

MOTOROLA FORM NO. SPD-1321

QUALITY CONTROL DISCREPANT PROCESS REPORT

Q.C. INSP.______________DATE:___________SHIFT:_____OPERATOR:________________

TYPE OF SAMPLE:______________SAMPLE SIZE:________TIME OF SAMPLE:_______________

SAMPLE RESULTS:____

CORRECTIVE ACTION PERFORMED:____

ACTUAL		APPEARANCE	
MISSING WIRE		< 3 BONDS	
EXCESSIVE LOOP		OFF BOND	
LIFTED BOND		BOND SPACING	
BROKEN WIRE		> 60° ANGLE	
MISBOND		INNER 2/3	
OVER-BOND		EXCESSIVE LOOP	
90° ANGLE		TAIL	
INC. BOND		EXTRA BOND	
CHOP. BOND		LIFTED BOND	
SMEAR. BOND		OVER-BOND	
WEAK BOND			
TAILS			
OFF BOND			
SHORT			
FOREIGN MATTER			
SUBSTRATE SHORTS			
LIFTED B. AREA			
EXCESSIVE WIRE			
METALIZATION			
DIE			

MOTOROLA FORM NO. SPD-1839-R1 • BACKER

DISCREPANT PROCESS REPORT LOG

Date Issued	Operation	Issued To	Reason	Date Ret'd	Date Issued	Operation	Issued To	Reason	Date Ret'd

Prepared by John Durso

MOTOROLA
Semiconductor
Products Inc.

PRODUCTION SPECIFICATIONS DEPARTMENT

IN-PROCESS Q.A. PROCEDURE

MCA54209W
NO. 12M51033C

PRODUCT GROUP: Integrated Circuits **PRODUCT LINE:**

TITLE: In-Process Q.A. Inspection Procedure for Dice after Scribe Visual

Scope: This specification covers the procedure to be followed in inspecting the following parts:

PART NUMBER	DESCRIPTION	USED ON
	Die, Si EPI	All Integrated Circuit Lines

Equipment Required:

B and L Microscope, 200X Power or Equivalent
Tygon (or equivalent) Tipped vacuum pick-up

Procedure:

1. Sampling Plan

1.1 Inspect (50) dice every (2) hours from each production inspector after scribing.

1.2 Inspect each die for all requirements under 2. (below).

2. Unit Processing

2.1 Inspect all dice under a microscope, 100X minimum magnification for the following categories of defects. Maintain a count of the number of defectives in each categorie and the total number of dice inspected. Maintain count on Motorola Form No. SPD-3313. See appropriate visual aids for typical defects.

~~2.1.1 Poor scribing~~
2.1.1 Cracked die
2.1.2 Hole in die
2.1.3 Bubbles in metal
2.1.4 Smeared metallization, scratched open, smeared metal shorts
(D) 2.1.5 Missing metallization, cavities, Inc. Metal
(D) 2.1.6 Unpassivated die
2.1.7 Glass in pads (passivated die)
2.1.8 Die that have not been probed
2.1.9 Evaporation errors
2.1.10 Pre-Ohmic Missing Metal

						SPECIFICATION
ES-6225	[illegible]	E				MCA54209W
ES-4213	[illegible]	D				NO 12M51033C
ES-2331	[illegible]	C				
MEMO	DATE	ISS	MEMO	DATE	ISS	PAGE 1 OF 7

2.1.11 Any other obvious defects
2.1.12 Metallization pulled away from stripe > 1/2 width

3. Data Processing

3.1 Compute the percent defective for total failures. This percent shall be figured on the basis of total sample size.

i.e. $\frac{\text{(total failures X 100)}}{\text{Total sample}}$

3.2 Maintain a percent defective chart Motorola Form No. SPD-1321 using the value obtained in 3.1.1. Plot (1) point per sample inspection.

3.3 Compute and maintain a percent defective chart for each inspector.

3.4 Compute and maintain a percent defective chart for the Q.A. dice inspection operation.

NOTE: All data generated by other shifts shall be kept on separate control charts.

3.5 Indicate on the charts any adjustment or change made to improve the process as well as any inadvertent change.

3.6 An "Out-of-Control" process shall be defined as one in which there are more than (1) reject dice. (1.0% AQL, MIL STD 105D, Level II) If this situation exists, a Discrepant Process Report, Motorola Form No. SPD-1633-R1, shall be issued to the cognizant production personnel. All discrepant process reports will be recorded on Motorola Form No. SPD-3814 at the time of issuance and the date recorded when returned. The discrepant process reports must designate corrective action taken and be signed by the production foreman and product engineer. All reports must be returned within a reasonable time. If the discrepant process reports are not returned within (48) hours, notify your Q.A. Supervisor for further investigation.

DIE INSPECTION-VISUAL REPORT

Date	Op.	Die No.	Q'ty In	Poor Scribing	Cracked Die & Cavities	Partial Die & Chipped Die	Damaged or Missing Metal	Inked Rejects	Smeared Metalization & Evap. Shorts	Accepted	Remarks

Semiconductor
Products Division

ASSEMBLY	DEVICE	CHARACTERISTIC	TOLERANCE
DEPT.	**SAMPLE SIZE**	**REMARKS**	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75

TIME	
DATE	
INITIALS	

QUALITY CONTROL DISCREPANT PROCESS REPORT

Q.C. INSP.______________ DATE:___________ SHIFT:_____ OPERATOR:________________

TYPE OF SAMPLE:_____________ SAMPLE SIZE:________ TIME OF SAMPLE:________________

SAMPLE RESULTS:____

CORRECTIVE ACTION PERFORMED:____

MOTOROLA FORM NO. SPD-1852-R1 FACE

ENGINEERING

ACTUAL		APPEARANCE	
MISSING WIRE		< 3 BONDS	
EXCESSIVE LOOP		OFF BOND	
LIFTED BOND		BOND SPACING	
BROKEN WIRE		> 60° ANGLE	
MISBOND		INNER 2/3	
OVER-BOND		EXCESSIVE LOOP	
90° ANGLE		TAIL	
INC. BOND		EXTRA BOND	
CHOP. BOND		LIFTED BOND	
SMEAR. BOND		OVER-BOND	
WEAK BOND			
TAILS			
OFF BOND			
SHORT			
FOREIGN MATTER			
SUBSTRATE SHORTS			
LIFTED B. AREA			
EXCESSIVE WIRE			
METALIZATION			
DIE			

MOTOROLA FORM NO. SPD-1033-R1 • BACKER

DISCREPANT PROCESS REPORT LOG

Date Issued	Operation	Issued To	Reason	Date Ret'd	Date Issued	Operation	Issued To	Reason	Date Ret'

Prepared by John Durso

MOTOROLA
Semiconductor
Products Inc.

PRODUCTION SPECIFICATIONS DEPARTMENT

IN-PROCESS Q.A. PROCEDURE

PRODUCT GROUP: Integrated Circuits PRODUCT LINE:

TITLE: In-Process Q.A. Inspection Procedure for Die Bonding - Visual

Scope: This specification covers the procedure to be followed in inspecting the following parts:

PART NUMBER	DESCRIPTION	USED ON
	Sub-Assembly, Die Bonded	All Integrated Circuit Lines

Equipment Required:

Bausch and Lomb Stereozoom, 60X Power or Equivalent
Tweezers, Probe

Procedure:

1. Sampling Plan

1.1 At least once during each shift, get and inspect (1) belt of die bonded units from each die bond Operator prior to production inspection. Inspect for all requirements under 2 below.

1.2 At least once during each shift, get and inspect (10) units minimum from each production inspector for all requirements under 2 below.

2. Unit Processing

2.1 Inspect all die bonded units under a microscope, magnification (60X minimum), for the following categories of defects. Maintain a count of the number of defectives and the total number of units inspected. Maintain count on Motorola Form No. SPD-1207. (See appropriate visual aids for typical defects)

2.1.1 Misplaced die: Device will be rejected if orientation of die is wrong, or if die is missing.

2.1.2 Bond Strength: To test bond strength, die are nudged lightly on side when there is no preform or pyro-ceram showing along edge.

2.1.3 Excessive preform

2.1.4 Preform on die

2.1.5 Obviously cracked or chipped die into isolation region or metallization.

2.1.6 Tipped die

ES-6225	[illegible]	D			
ES-4213	[illegible]	C			
ES-2909	[illegible]	B			
MEMO	DATE	ISS	MEMO	DATE	ISS

SPECIFICATION
MCA5421OW
NO. 12M518340

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2.1.7 Pyroceram or preform on post

2.1.8 Loose preform or metallic particles on header or in flat pack

2.1.9 Partial or incomplete die

2.1.10 Preform extending over die and touching or beyond scribe line area.

2.1.11 Inked die

2.1.12 Any other obvious defects (bad header plating, bad pins, etc.).

2.2 Poor Workmanship

2.2.1 Pyroceram or preform on die, post or header

Poor workmanship units are to be taken immediately to the foreman for corrective action.

3. Data Processing

3.1 Compute the percent defective for total failures for each die bond operator and each production inspector. This percent shall be figured on the basis of total sample size. (Not including poor workmanship units)

i.e. $\frac{\text{(total failures}}{\text{total sample}}$ X 100)

3.2 Maintain a percent defective chart (Motorola Form No. SPD-1321) using the value obtained in 3.3. Plot (1) one point per sample inspection.

NOTE: All data generated by other shifts shall have the percent points kept on separate control charts.

3.3 Indicate on the charts any adjustment or change made to improve the process as well as any inadvertent change.

3.4 An "Out-of-Control" process shall be defined as one in which there are > 1 defects. If this situation exists, a Discrepant Process Report, Motorola Form No. SPD-1833-R1, shall be issued to the cognizant production personnel. All Discrepant Process Reports will be recorded on Motorola Form No. SPD-3814 at the time of issuance and the date recorded when returned. The Discrepant Process Reports must designate corrective action taken and be signed by the production foreman and product engineer. All reports must be returned within a reasonable time. If the Discrepant Process Reports are not returned within (48) hours, notify your Q.A. Supervisor for further investigation.

4. Should any question arise concerning these inspection procedures, contact your immediate Q.A. Supervisor.

5. All inspected units will be returned to the device assembly area to be processed in normal manner.

DIE BOND INSPECTION LOG SHEET

DATE: ____________ INSPECTOR: ____________

DEVICE	LOT NO.	MACHINE NO.	OPERATOR	UNITS IN	MISPLACED DIE A	BOND STRENGTH B	SCR. OR MISS. METAL'N C	FOREIGN MAT. ON DIE D	CRACKED OR CHIPPED DIE E	TIPPED DIE F	MISC. G	ACC[illegible] H

Semiconductor Products Division

ASSEMBLY	DEVICE	CHARACTERISTIC	TOLERANCE
DEPT.	SAMPLE SIZE	REMARKS	

TIME

DATE

INITIALS

MOTOROLA FORM NO. SPD-1321

QUALITY CONTROL DISCREPANT PROCESS REPORT

Q.C. INSP.______________ DATE:___________ SHIFT:_____ OPERATOR:__________________

TYPE OF SAMPLE:_____________ SAMPLE SIZE:________ TIME OF SAMPLE:________________

SAMPLE RESULTS:____

____

____

____

____

CORRECTIVE ACTION PERFORMED:____

____

____

____

____

ACTUAL		APPEARANCE	
MISSING WIRE		$<$ 3 BONDS	
EXCESSIVE LOOP		OFF BOND	
LIFTED BOND		BOND SPACING	
BROKEN WIRE		$>$ 60° ANGLE	
MISBOND		INNER 2/3	
OVER-BOND		EXCESSIVE LOOP	
90° ANGLE		TAIL	
INC. BOND		EXTRA BOND	
CHOP. BOND		LIFTED BOND	
SMEAR. BOND		OVER-BOND	
WEAK BOND			
TAILS			
OFF BOND			
SHORT			
FOREIGN MATTER			
SUBSTRATE SHORTS			
LIFTED B. AREA			
EXCESSIVE WIRE			
METALIZATION			
DIE			

MOTOROLA FORM NO. SPD-1033-R1 - BACKER

DISCREPANT PROCESS REPORT LOG

Date Issued	Operation	Issued To	Reason	Date Ret'd	Date Issued	Operation	Issued To	Reason	Date Ret'd

Motorola Semiconductor Products Inc.

ENGINEERING & MANUFACTURING SPECIFICATIONS DEPARTMENT

PROCESS SPEC

REVISION RECORD SHEET

PRODUCT GROUP: INTEGRATED CIRCUITS PRODUCT LINE:

TITLE: IN-PROCESS Q.A. INSPECTION PROCEDURE FOR WIRE BONDING - VISUAL

SPD 4520

NO. MCA5421W

REV.	ES	DATE	ASC CODE	DESCRIPTION OF CHANGE
H	7458	8-31-66	IC-811	Deleted section 2.2, ultrasonic bonding. Re-numbered 2.3 thru 2.3.11.
J	ES-8150	10-6-66	IC-968	Changed 2.2.1, 2.2.5, 2.2.11

PRINT NO.

NO. MCA5421W

PAGE 1 OF 1 PAGES

Prepared by John Durso

PRODUCTION SPECIFICATIONS DEPARTMENT

IN-PROCESS Q.A. PROCEDURE

PRODUCT GROUP: Integrated Circuits PRODUCT LINE:

TITLE: In-Process Q.A. Inspection Procedure for Wire Bonding - Visual

NO. MCA5421lW RWS

Scope: This specification covers the procedure to be followed in inspecting the following parts:

PART NUMBER	DESCRIPTION	USED ON
	Sub-Assembly, Wire Bonded	All Integrated Circuit Lines

Equipment Required:

Bausch and Lomb Stereozoom Microscope, 50X Power minimum or equivalent

Tweezers, Plexiglass Inspection Rack

Procedure:

1. Sampling Plan

1.1 At least once during each shift, get and inspect (1) Belt of wire bonded units from each wire bond operator prior to production inspection. Inspect for all requirements under 2 below.

1.2 At least once during each shift, get and inspect (10) units minimum from each production inspector for all requirements under 2 below.

2. Unit Processing

Inspect all wire bonded units under a microscope 50X minimum magnification, for the following categories of defects and poor workmanship. Maintain a count of the number of defectives and the total number of units inspected. Maintain count on Motorola Form No. SPD-1827-R1.

2.1 Defects for Wire Bond Operator and Inspector

Refer to visual aids for typical defects.

2.1.1 Missing Wires

2.1.2 Lifted Bond on die or post

2.1.3 Wire Broke at die or post

2.1.4 Too much loop or sag in wires

2.1.5 More than (1) over bond/pad
2.1.6 Mis-bonds
2.1.7 Wire shorts
2.1.8 Bond off wires
2.1.9 Excessive Wires
2.1.10 More than approx. 1/3 of bond off of pad
2.1.11 Tail left at post or die
2.1.12 Wires twisted greater than 30° from bond
2.1.13 Foreign matter
2.1.14 Chopped bond
2.1.15 Incomplete bond - less than 2/3 bond
2.1.16 Week bonds (no spreading of wire diameter)
2.1.17 Partially lifted bonds
2.1.18 Wire touching edge of die
2.1.19 Wire defects
2.1.20 Loose metallic particles (beads, flakes, particles, etc.)
2.1.21 Smeared bond on die or post
2.1.22 Missing Metallization (incomplete metallizing and cavities) Hi-Power
2.1.23 Smeared Metallization - Hi-Power
2.1.24 Scratches or cracks across active area - Hi-Power
2.1.25 Device not probed - Hi-Power
2.1.26 More than 1/4 bonding pad missing - Hi-Power
2.1.27 Any other obvious defects

H

2. Poor Workmanship for Operators

J

2.2.1 Less than 2 bonds on post
2.2.2 One or more bonds lifted on post

2.2.3 Repeated bonding at stripe or post

2.2.4 Extra bond on pad or post

(J) 2.2.5 Pad tails greater than 2 wire dia.

2.2.6 Any part of bond off of pad

2.2.7 Apparent wire bond shorts

2.2.8 Tight wire

2.2.9 Excessive tails

2.2.10 Over bond

(J) 2.2.11 Wires twisted greater than 5° from bond except MECL & Hybrid, poor workmanship units are to be taken immediately to the foreman for corrective action.

3. <u>Data Processing</u>

3.1 Compute the percent defective, appearance (poor workmanship) and actual (defects) rejects for total failures for each wire bond operator and each production inspector. This percent shall be figured on the basis of the total sample size, i.e.

$$\frac{\text{total failures}}{\text{total sample}} \times 100$$

3.2 Maintain a percent defective chart, Motorola Form No. SPD-1321, using the values obtained in 3.1. Plot (1) point per sample inspection.

NOTE: All data generated by other shifts shall be kept on separate control charts.

3.3 Indicate on the charts any adjustment or change made to improve the process as well as any inadvertent change.

3.4 An "Out of Control" process shall be defined as one in which there are > 1 defects. If this situation exists, a Discrepant Process Report, Motorola Form No. SPD-1833-R1, shall be issued to the cognizant production personnel. All Discrepant Process Reports will be recorded on Motorola Form No. SPD-3814 at the time of issuance and the date recorded when returned. The Discrepant Process

Reports must designate corrective action taken and be signed by the production foreman and product engineer. All reports must be returned within a reasonable time.

4. Should any question arise concerning these inspection procedures, contact your immediate supervisor.

5. All inspected units will be returned to the device assembly area to be processed in the normal manner.

WIRE BOND INSPECTION

DATE____________________

					ACTUAL REJECTS																			APPEARANCE REJECTS																
DEVICE	LOT #	MACHINE NUMBER	OPERATOR	UNITS IN	MISSING WIRE	EXCESSIVE LOOPS	LIFTED BONDS	BROKEN WIRE	MIS BOND	OVER BOND	30° ANGLE TWIST	INCOMPLETE BOND	CHOPPED BOND	SMEARED BOND	WEAK BOND	OFF BOND	SHORT	BOND OFF	EXCESSIVE WIRE	CHOPPED BOND	POST TAIL	SUBSTRATE SHORT	LOOSE PARTICLES		LIFTED POST BOND	LESS THAN 3 BONDS	OFF BOND	BOND NOT SPACED	INNER 2/3	EXCESSIVE LOOPS	SHORT	CHOPPED BOND	SMEARED BOND	WEAK BOND	EXTRA BOND				ACCEPTED	# ACTUAL REJECTS	# APPEARANCE REJECTS

MOTOROLA FORM NO. SPD-1827-R2

Semiconductor Products Division

ASSEMBLY		DEVICE	CHARACTERISTIC	TOLERANCE
DEPT.	SAMPLE SIZE	REMARKS		

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75

TIME

DATE

INITIALS

QUALITY CONTROL DISCREPANT PROCESS REPORT

Q.C. INSP.____________ DATE:__________ SHIFT:_____ OPERATOR:____________

TYPE OF SAMPLE:____________ SAMPLE SIZE:_______ TIME OF SAMPLE:____________

SAMPLE RESULTS:____________________________________

CORRECTIVE ACTION PERFORMED:____________________________

MOTOROLA FORM NO. SPD-1833-R1 FACE

ENGINEERING

ACTUAL		APPEARANCE	
MISSING WIRE		$<$ 3 BONDS	
EXCESSIVE LOOP		OFF BOND	
LIFTED BOND		BOND SPACING	
BROKEN WIRE		$> 60^{\circ}$ ANGLE	
MISBOND		INNER 2/3	
OVER-BOND		EXCESSIVE LOOP	
90° ANGLE		TAIL	
INC. BOND		EXTRA BOND	
CHOP. BOND		LIFTED BOND	
SMEAR. BOND		OVER-BOND	
WEAK BOND			
TAILS			
OFF BOND			
SHORT			
FOREIGN MATTER			
SUBSTRATE SHORTS			
LIFTED B. AREA			
EXCESSIVE WIRE			
METALIZATION			
DIE			

DISCREPANT PROCESS REPORT LOG

Date Issued	Operation	Issued To	Reason	Date Ret'd	Date Issued	Operation	Issued To	Reason	Date Ret'd